# CORRELATION BETWEEN SEGMENT LENGTH AND SPINE COUNTS IN TWO SPIDER SPECIES OF ARANEUS (ARANEAE: ARANEIDAE)* 

By L. David Carmichael<br>Museum of Comparative Zoology


#### Abstract

Observations made on several hundred adult male spiders of two species of Araneus indicate a highly significant correlation ( $\mathrm{p}<0.00 \mathrm{I}$ ) between the length of a segment (tibia of the second leg) and the number of macrosetae ("spines") present on the segment. This result is further supported by observations on the first tibiae of about twenty male $A$. trifolium, one of the two species, and by a few observations on immatures of the two species. A short summary of the methods used in taking the measurements and making the calculations is followed by discussion of the implications of this correlation with reference to species determination and geographic variation.


## Methods

The study was done on two species of common North American spiders, Araneus trifolium (Hentz) and $A$. marmoreus Clerck. 185 male specimens of $A$. trifolium yielded 347 tibiae of the second leg (some specimens had lost one leg) ; the length of this segment was measured, and the number of spines on the segment was counted. In addition, lengths and spine counts were taken for the first tibiae of 23 of the spiders, yielding 4I observations. Similarly, 120 specimens of $A$. marmoreus yielded 21о second tibiae; the length was measured, and two spine counts were made: the total number on the tibia, and the number of modified, "dentiform" ${ }^{1}$ spines (see Figure 3). The samples of both species were museum collections, and represented almost the entire known range of each in North America, extending from coast to coast and roughly from the 35th to the 55th parallels.

The spines of the second tibia, like all the spines of these spiders, are actually setae in the entomological sense; they are set in a socket

[^0]

Figures 1 and 2. A. trifolium tibia II, right leg. 1, anterior (prolateral) surface; 2, posterior (retrolateral) surface.
Figures 3 and 4. $A$. marmoreus tibia II, right leg. The dentiform spines are blackened. 3, anterior (prolateral) surface; 4, posterior (retrolateral) surface.

Note the difference in scale between 1, 2 and 3, 4 .
of the cuticle, and are movable. Thus even when the spine itself becomes detached and lost, as is common with preserved specimens, its presence or absence can be determined unequivocally by the presence or absence of the setal socket.

In the two species examined, the spines are uniformly larger than the hairs which are also present, the former having a diameter at the base of roughly 0.03 to 0.06 mm , while the latter are five to ten times smaller. In $A$. marmoreus, there is a second type of spine, described as dentiform, which is roughly 0.07 to 0.10 mm at the base. Since this constituted a distinct group, it was counted separately.

Finally, the spines in both species are arranged in fairly constant patterns, particular to the species (see Figs. 1-4). This makes it possible to recognize each spine, which further eliminates any uncertainty as to the number of spines. These thiree factors, the clear difference between spines and hairs, the presence of a socket whether or not the spine itself has been lost, and the possibility of recognizing each spine, make the spine counts unambiguous and as accurate as possible within the limits of observor error.

The length of the tibia was measured along the dorsal midline of the segment, between points " $a$ " and " $b$ " as shown in Figures I and 3. A grid in the microscope eyepiece, each cell of which measured 0.325 mm on a side (as determined with a stage micrometer), permitted accuracy to $\pm 0.02 \mathrm{~mm}$, or about $\pm 1 \%$.

The treatment of the data followed standard statistics texts; the actual calculations were performed by the Harvard SDS 940 digital computer.

## Results

Table I presents the correlation coefficient for the number of spines versus the segment length in the four different samples, as well as the coefficient of regression (b) and the results of the $t$-test for $\mathrm{b}=\mathrm{o}$. These values indicate that in all four cases the correlation is highly significant (i.e. significant at the $0.1 \%$ level). b, the coefficient of regression, quantifies the relationship established here; it is the slope of the estimated regression line drawn in Graphs I and II. The line is:
(number of spines) $=\mathrm{a}+\mathrm{b} \times$ (length of tibia)
Table II gives the mean and variance for the two variables in both species, and the mean absolute difference between right and left legs of individual specimens. In general the results are very


Graph I. Scatter diagram and estimated regression line for A. trifolium measurements. $\mathrm{b}=2.75, \hat{\mathrm{a}}=15.24$, (expected number of spines) $=\hat{\mathrm{a}}+$ b $\times$ (tibia length). Open circle, adult specimens; closed circle, immature specimens; triangles, mean spine counts for given tibial length.
similar to those found by Beatty (1967) for Adriana: the spine count is quite constant within each species, though few specimens are actually identical. Furthermore, in the two species of Araneus, as in Ariadna, almost no individuals are completely symmetrical in pattern, and most are asymmetric in actual spine counts. Beatty attributed such differences within and between individuals to developmental "accidents"; it is clear, however, that in the case of Araneus some of the variation between individuals is specifically related to difference in size. But for any single specimen the difference in spine count (between left and right legs) seems not to be correlated with the difference in segment length. (This correlation is calculated as $\mathrm{r}_{2}$ in Table in II ; the values, though positive, are not significant at the $5 \%$ level.) Thus Beatty's assertion is correct for individual spiders; differences between left and right legs do seem to be due to developmental accidents, and quite independent of each other. This point will be important in the following discussion.

## Discussion

It is important first to note that the above correlation does not in itself imply cause and effect; this is clear from the fact that for any individual, segment length and spine count are not correlated. It is likely that both the length of the segment and the number of spines are dependent on some other factor, such as general body size, etc.

One obvious possibility is that both measurements are related to the degree of development, that is, to the number of molts the spider has undergone. In most spiders raised there is some variation in the number of preadult instars within a species. Furthermore, it is not known with certainty at what stage these spiders mature or how many molts occur after maturation, so this possibility cannot be examined with the data available. All the calculations here are based on sexually mature specimens, but their ages cannot be determined more precisely. Consequently, part of the spine count variation may be dependent on this unmeasured variable; of course, size is somewhat dependent on this variable too.

On the basis of the data presented here, the best statement is simply that spine count is very significantly correlated with segment length, in these two species of A raneus.

Then there is the question of geographic variation. The samples studied represent a pool of many local populations in North America, and it is possible that the relationship between segment length and spine count is different in different regions. (Preliminary examination of the data with regard to this question indicate that this is in


Graph II. Scatter diagram and estimated regression lines for $A$. marmoreus measurements. Upper part of graph (open circles) shows total spine counts: $\mathrm{b}=4.43, \mathrm{a}=16.52$. Lower part of graph (closed circles) shows dentiform spine counts only: $\mathrm{b}=1.44, \mathrm{a}=8.12$. Triangles show mean spine counts for given tibial length.

## TABLE I

|  | A. trifolium |  | A. marmorcus |  |
| :---: | :---: | :---: | :---: | :---: |
|  |  |  | Total | Dentiform |
|  | Tibiae II | Tibiae I | count | only |
| N | 347 | 41 | 210 | 210 |
| $\mathrm{r}_{1}$ | 0.54 | 0.61 | 0.63 | 0.42 |
| b | $2.75 \pm 0.60$ | $2.39 \pm 1.36$ | $4.43 \pm 1.00$ | $1.44 \pm 0.56$ |
| t -test | 12.0 | 4.8 | 11.6 | 6.7 |
| $($ for $\mathrm{b}=0)$ |  |  |  |  |

Calculation of correlation and regression coefficients for spine counts versus lengths of first and second tibiae of $A$. trifolium and for total and dentiform spine counts versus length of second tibia of $A$. marmoreus. $\mathrm{r}_{1}$ is the correlation coefficient for spine counts versus length; $b$ is the slope of the regression line, presented with its $99 \%$ confidence intervals. The significance of the correlation may be found either from the value of the coefficient r or from the t -test on the null-hypothesis $\mathrm{b}=0$.
fact the case.) While this does not affect the validity of the results as they have been presented, it would modify the quantitative relationship (expressed by b) significantly in separated areas. This question is open to further study; its significance will be mentioned below.

## Conclusion

The correlation between the number of spines on a segment and the length of the segment is important to at least two aspects of Araneology: taxonomy and the study of geographic variation. Macrosetal counts have often been used to distinguish between different genera of spiders ${ }^{2}$, as well as between species of one genus such as Araneus. If the situation described in this paper is a general one, then clearly any character based on setal counts should be used for taxonomic purposes only after careful study. In general, it would seem from observations on these two species of Araneus that the number of spines alone is not highly reliable, but the pattern is quite constant within a species (or at least recognizable, though spines may be missing, or present in "unusual" locations). This is supported by observations made on species of the genus Neoscona (Berman and Levi (197I), p. 467).

Secondly, in studying geographic variation, it is necessary at least in this case to consider the mean dimensions of local populations as well as the spine counts. A marked variation in spine count between

[^1]TABLE II


Self-explanatory: the means are presented with their $99 \%$ confidence intervals. See text for details.
two regions might be obscured by the fact that specimens from one of the regions are generally smaller than those from the other (which itself might be due to significant geographic variation in size, or to differences in sampling techniques, etc.).

## Acknowledgments

I wish to thank Dr. H. W. Levi, my advisor at the time this study was done, for his advice and patient help; Dr. S. J. Gould, who advised me on the interpretation of statistical data; and the late Mr. Ivie of the American Museum of Natural History, who loaned me specimens from that museum. While doing the research for this paper, I was supported until June, 1969 by a scholarship from the National Merit Foundation, and subsequently by an NDEA title IV fellowship.

## References

Beatty, J. A.
1967. The Spider Genus Ariadna in the Americas. Doctoral Thesis, Harvard University, Dept. of Biology.
Berman, J. D. and H. W. Levi
1971. The Orb Weaver Genus Neoscona in North America (Araneac: Araneidae). Bull. Mus. Comp. Zool. 141 (8) : 465-500.
Kaston, B. J.
1948. Spiders of Connecticut. Bull. Conn. Geol. Natur. Surv. Vol. 70 : 1-874.
Locket, G. H., and A. F. Millidge
1953. British Spiders, 2. Ray Society (London).

Simpson, G. G., A. Roe, and R. C. Lewontin
1960. Quantitative Zoology (2nd ed.). Harcourt, Brace \& World, Inc. Wetherill, G. B.
1967. Elementary Statistical Methods. Methuen \& Co.


[^0]:    *Manuscript received by the editor January 10, 1973
    ${ }^{1}$ Term used by Locket \& Millidge (1953), pp. 120, 121.

[^1]:    ${ }^{2}$ For examples, see Kaston (1948), with reference to: Gnaphosidae (Drassodidae) pp. 347, 354; Clubionidae, pp. 367, 382; Thomisidae, pp. 410, 440; and Salticidae, p. 445.

